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(71) Applicant(s)

Mitsubishi Denki Kabushiki Kaisha

(Incorporated in Japan)

No. 2-3 Marunouchi 2-chome, Chiyoda-ku, Tokyo 100,
JapanMitsubishi Electric Semiconductor Software
Corporation Ltd

(Incorporated in Japan)

1-17, Chou 3-Chome, Itami Shi, Hyogo 664, Japan

(72) Inventor(s)

Taiyuu Miyamoto

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(74) Agent and/or Address for Service

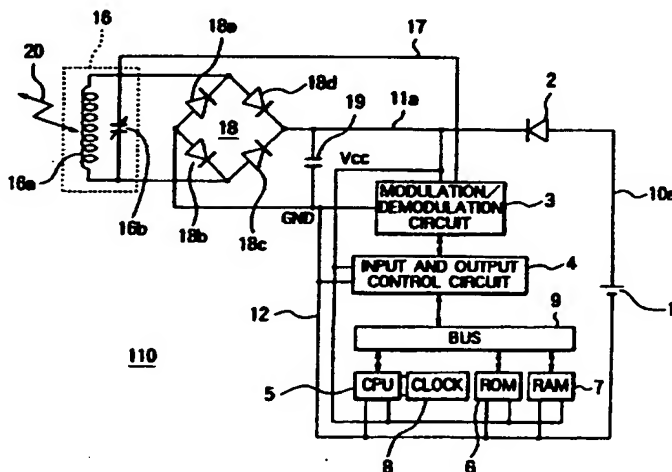
Marks & Clark

57-60 Lincoln's Inn Fields, LONDON, WC2A 3LS,
United Kingdom

(54) Power supply for non-contact IC card

(57) A non-contact IC card has an antenna circuit 16 for receiving and transmitting data via an electromagnetic wave 20, a rectifier 18 and a capacitor 19 providing power for supplying the card by rectification of the received communication signal 20, and a battery 1 which acts as a backup power supply for data stored in a RAM 7 and also powers the card when the received electromagnetic wave 20 is weak. The dual power supply 1, 18, 19 has the advantages of both the prior battery-powered and batteryless types of IC card in achieving long battery and card life and also long communication distance. The battery 1 may be a primary battery with switching between the two power supplies being effected by a diode 2, or by an IC power control chip (14, Figs. 2, 3) which compares the voltage on capacitor 19 with a reference voltage indicative of the card operating voltage. The battery may alternatively be a rechargeable battery charged from the capacitor 19 (Fig. 4).

FIG. 1



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FIG. 1

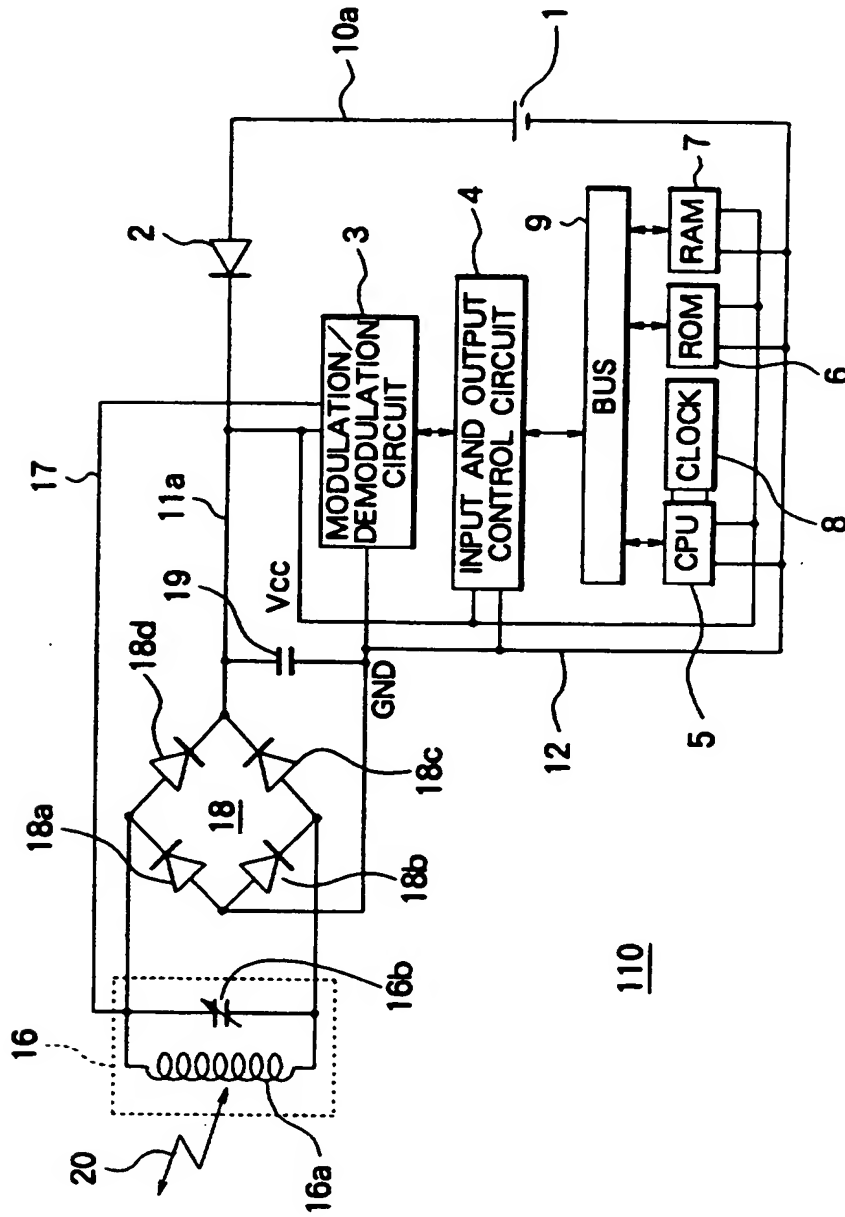


FIG. 2

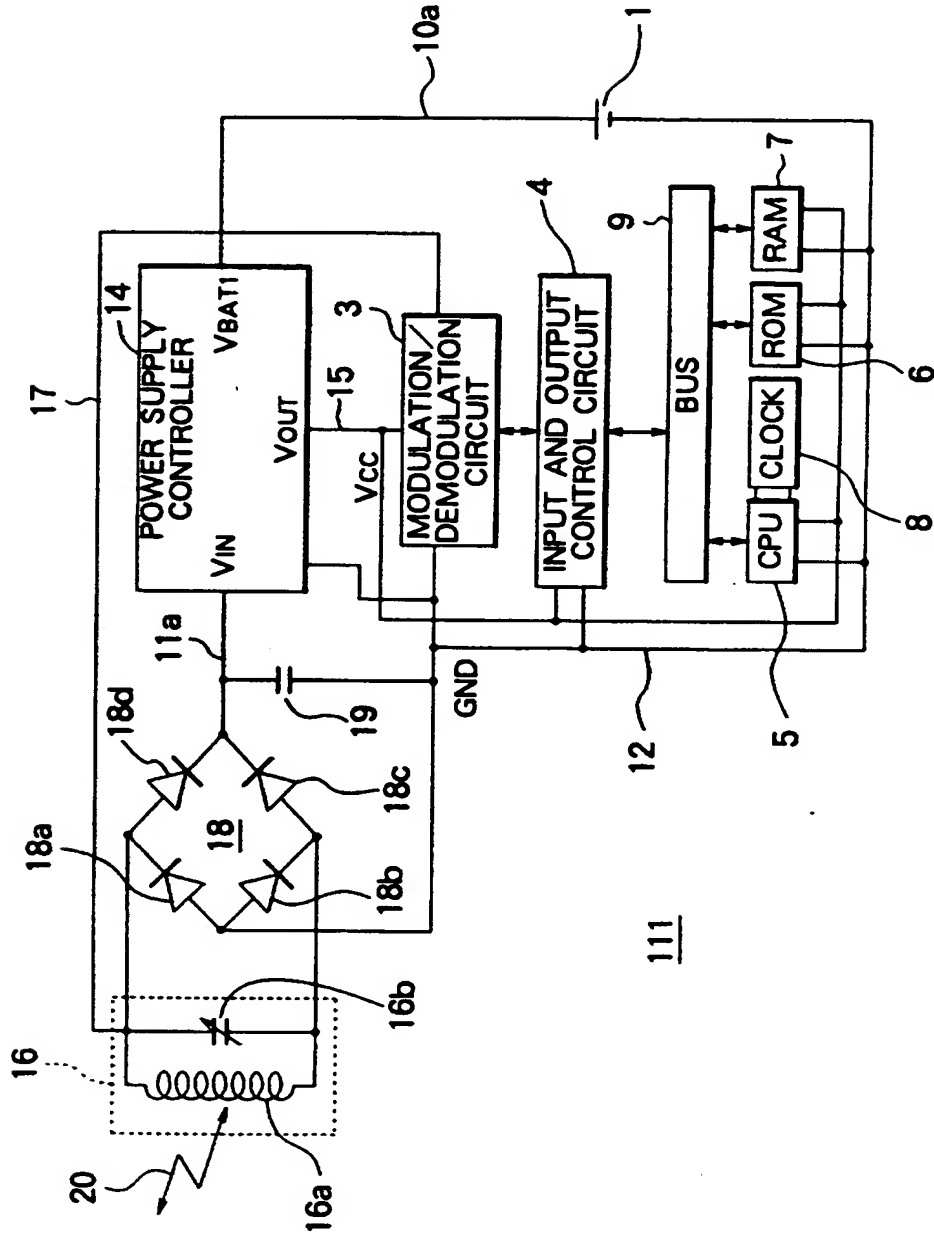


FIG. 3

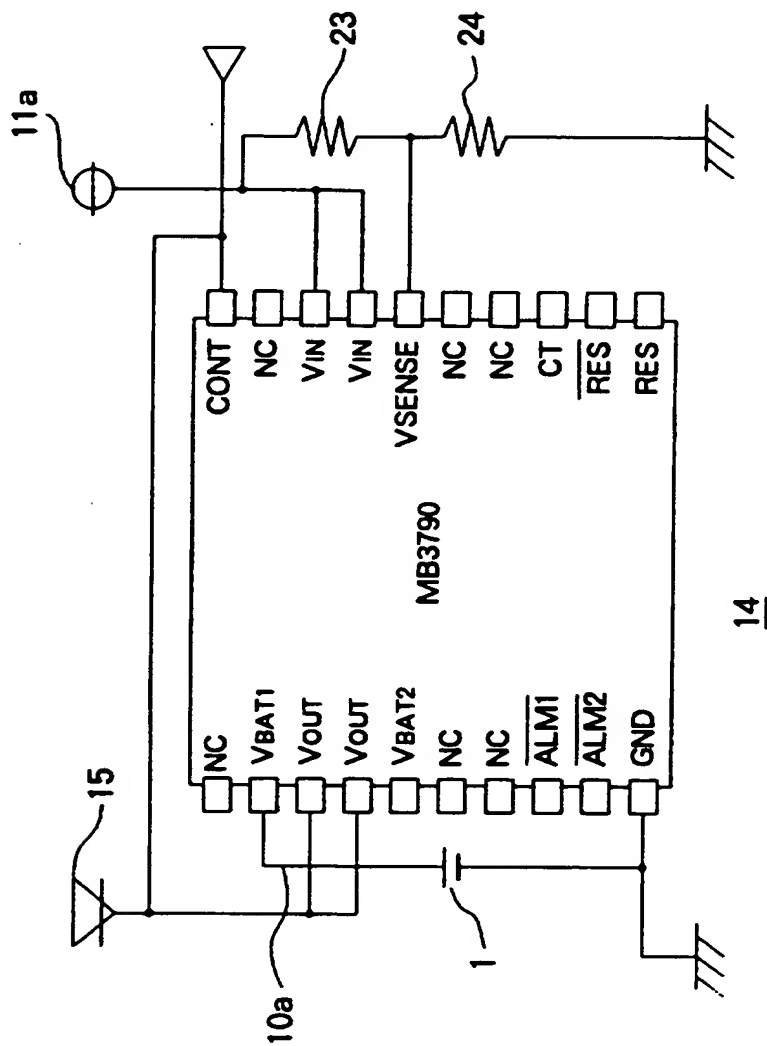


FIG. 4

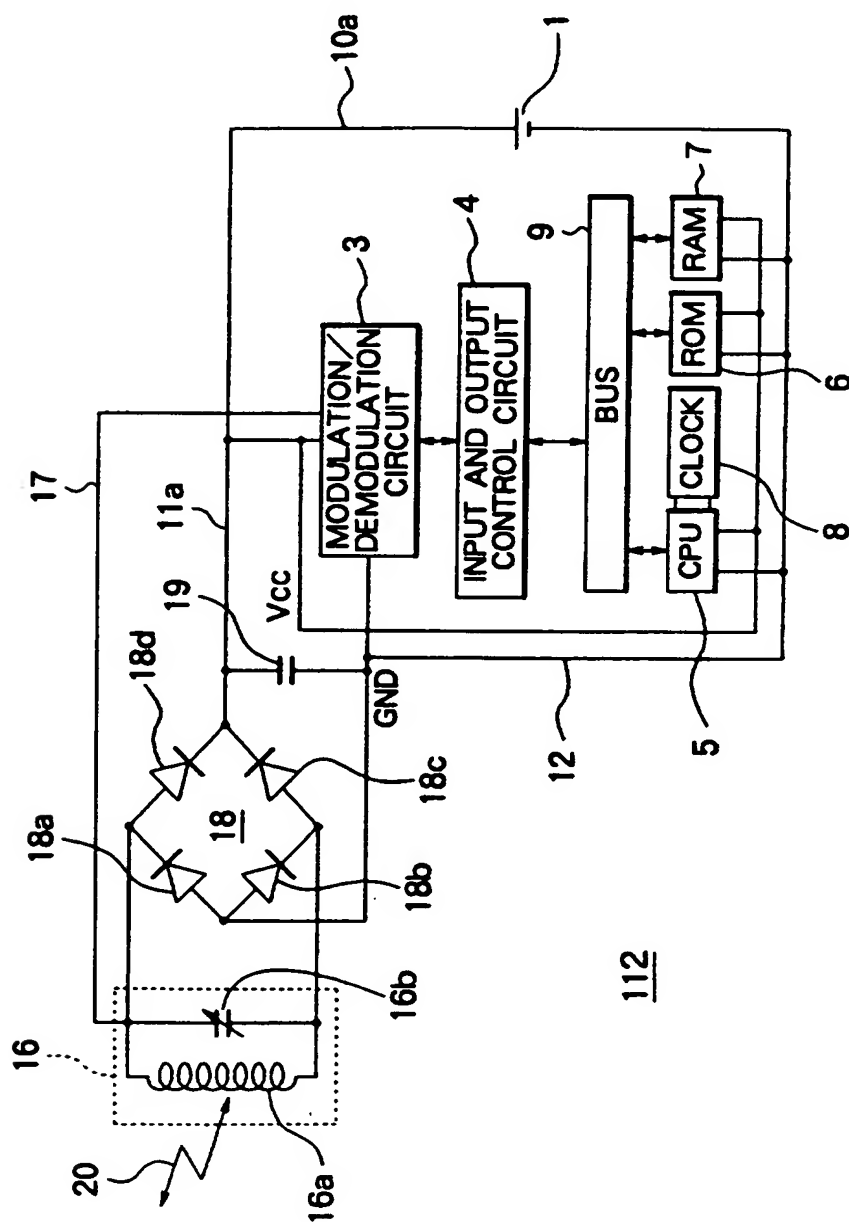
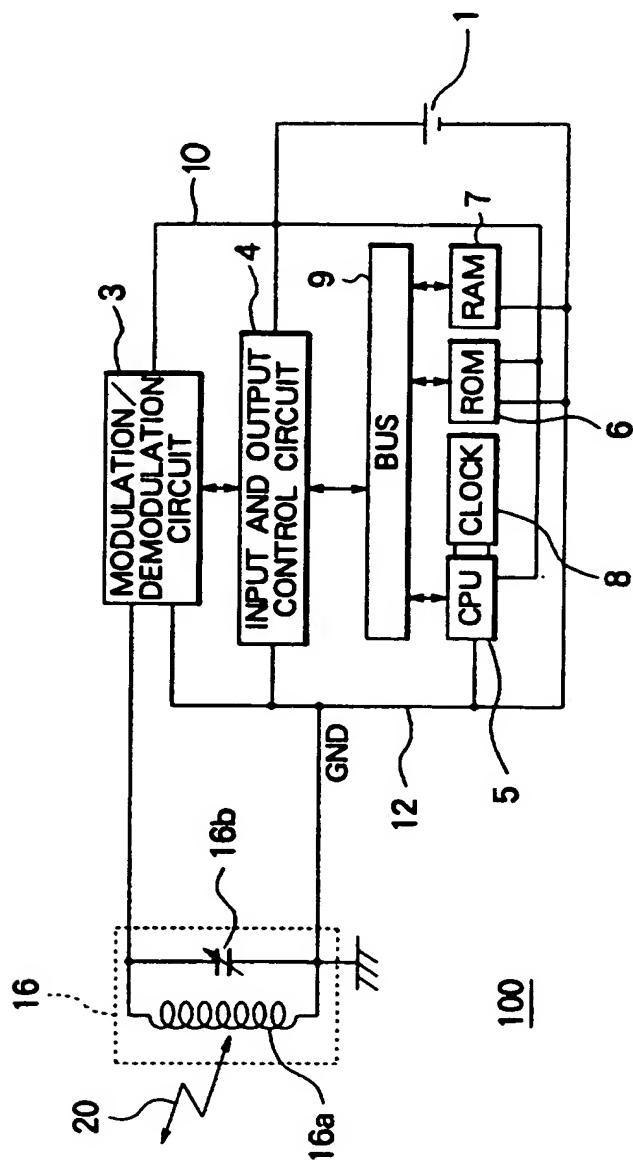


FIG. 5



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FIG. 6

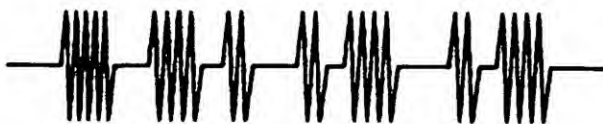


FIG. 7

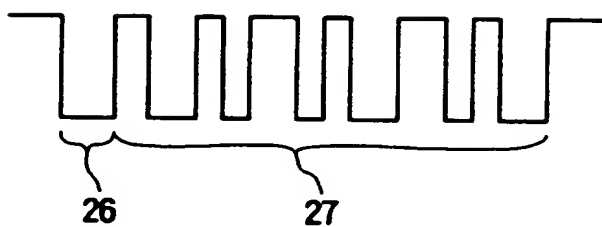


FIG. 8

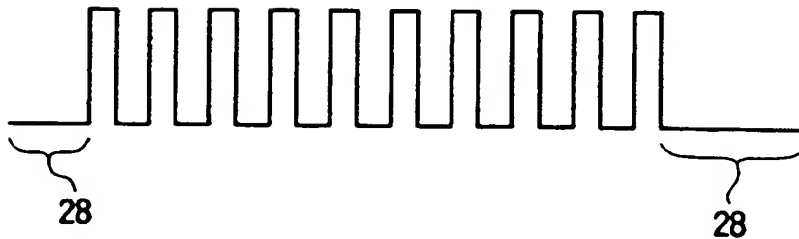


FIG. 9

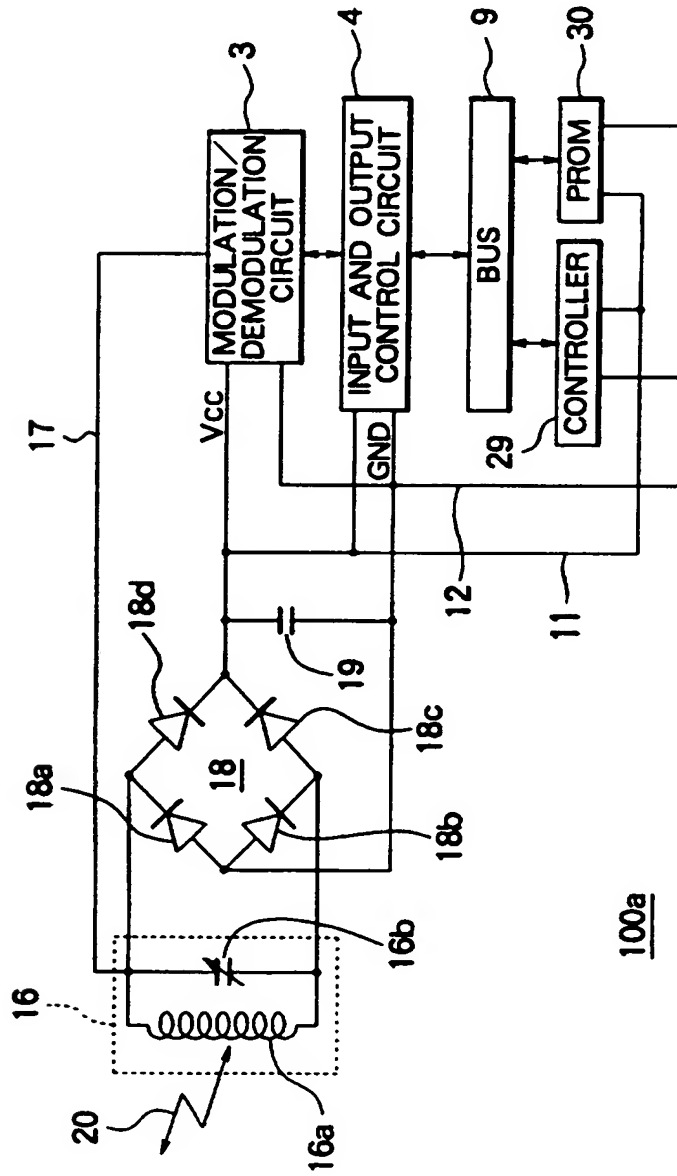


FIG. 10

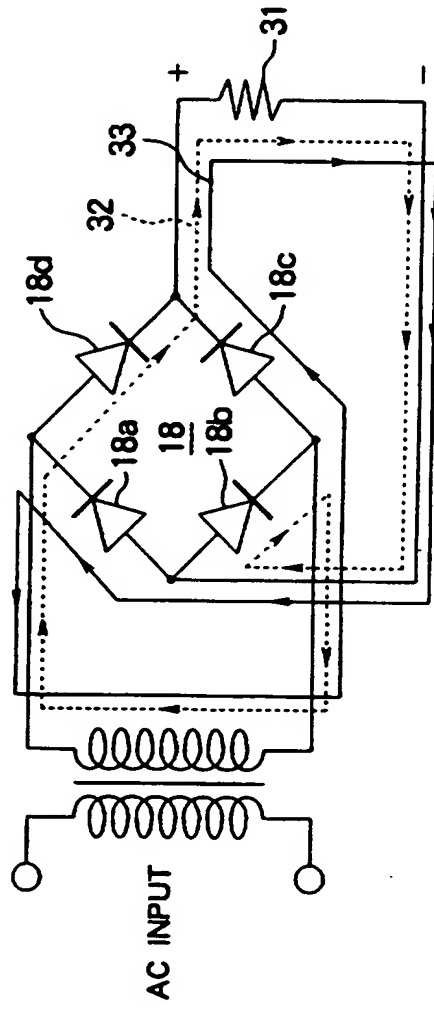
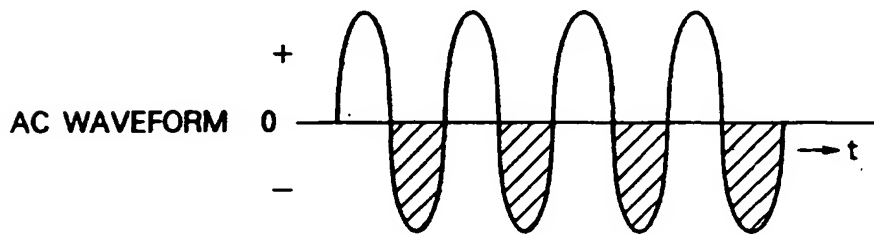
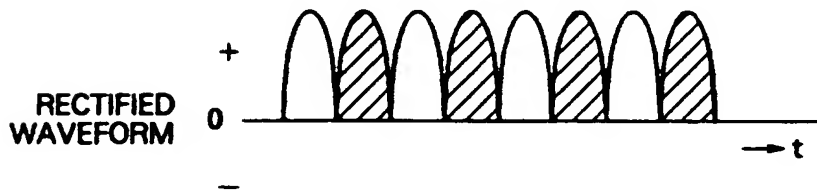
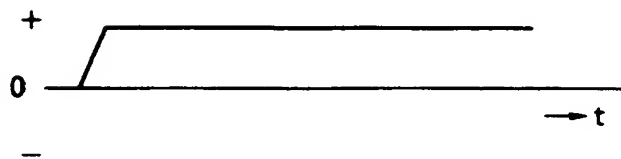


FIG. 11**FIG. 12****FIG. 13**

NON-CONTACT IC CARD

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a non-contact IC card having the capability of transmitting and receiving data using an electromagnetic wave as a communication media, and particularly to a power supply technique of such a non-contact IC card.

DESCRIPTION OF THE RELATED ART

Conventional non-contact IC cards can be classified, according to the type of a power supply, as a battery-powered type and a batteryless type. The battery-powered card has a built-in battery whereas the batteryless card is powered by an external power source by means of electromagnetic coupling or via an electromagnetic wave. In battery-powered cards, the battery life ranges from 2 to 8 years depending on the frequency in use. In some cases, however, great consumption of power occurs owing to erroneous operations or erroneous start caused by for example noise. On the other hand, batteryless cards have a disadvantage that the communication distance is limited to a shorter range than battery-powered cards.

Among the conventional non-contact IC cards using a radio wave as a communication medium, a battery-powered non-contact IC card powered by a built-in battery is shown in Figure 5. In this battery-powered non-contact IC card (referred to simply as card hereinafter) 100, reference numeral 1 denotes a primary battery 1 for supplying electric power via a power line 10 to various circuits in the card 10. Reference numeral 12 denotes a GND (ground) line.

Reference numeral 16 denotes an antenna circuit 16 for

transmitting and receiving information to and from an external device via a radio wave 20. The antenna circuit 16 includes an antenna 16a in the form of a coil and a capacitor 16b wherein the antenna circuit 16 is tuned at the same resonant frequency as the antenna of the external device such as a reader/writer (not shown). Reference numeral 5 denotes a CPU for processing data according to a user program. Reference numeral 6 denotes a ROM for storing the user program. Reference numeral 7 denotes a RAM for temporarily storing data. Reference numeral 8 denotes a clock for generating a clock signal in response to which the CPU 5 operates. Reference numeral 9 denotes a bus via which data and addresses are transmitted. Reference numeral 3 denotes a modulation/demodulation circuit for modulating a digital signal received from an input and output control circuit 4 into an analog signal and also demodulating a analog signal received via the antenna 16a into a digital signal, wherein the input and output control circuit 4 converts the data from parallel and serial forms into serial and parallel forms, respectively, before transferring the data between the bus 9 and the modulation/demodulation circuit 3.

The battery-powered card 100 operates in a manner described below.

The card 100 transmits and receives data to and from the reader/writer (not shown) using an electromagnetic wave 20 as a communication medium. The card is usually in a standby state in which the clock operation is stopped so as to reduce the battery power consumed by the card. The card starts an operation only when it has received a signal from the reader/writer. The received signal includes a trigger (TRG) signal in response to which the card operation is started, and a data signal (a communication command) to be dealt with in the

card.

Figures 6 through 8 illustrate waveforms of signals which are obtained at various portions of the card 100 in Figure 5 when the card receives a trigger signal 26 for triggering the card operation (a signal in response to which the CPU 5 starts its operation), and also receives a data signal 27 (communication command) to be dealt with in the card, wherein Figure 6 illustrates a waveform of a received electromagnetic wave 20, Figure 7 illustrates a waveform of a digital signal converted from the electromagnetic wave shown in Figure 6, and the Figure 8 illustrates a waveform of a clock signal that is generated when the electromagnetic wave 20 shown in Figure 6 is received.

When the card is in a standby state, the clock 8 generates no signal as illustrated by a waveform 28 in Figure 8. If the card 100 receives a signal such as that shown in Figure 6 from for example the reader/writer, the received signal is demodulated into a digital signal by the modulation/demodulation circuit 3, and the resultant signal is transferred to the input and output control circuit 4. The input and output control circuit 4 converts the received serial data into parallel data, and transfers the resultant data via the bus 9 to the CPU 5, the RAM 7, or other portions of the card. After the CPU 5 has processed the data, the input and output control circuit 4 receives the resultant data in parallel form. The input and output control circuit 4 converts the received data into serial form, and transfers the resultant data to the modulation/demodulation circuit 3. The modulation/demodulation circuit 3 modulates the received digital data in serial form into analog form, and transmits the resultant analog signal using an electromagnetic wave 20 via the antenna 16.

When the card 100 receives an end command from the reader/writer, the card 100 returns to a standby state (denoted by reference numeral 28 in Figure 8). If no valid communication command 27 is received after a trigger signal 26, the card 100 returns to a standby state 28 regardless of reception of an end command. In the battery-powered card 100, before receiving a trigger signal, the card 100 is maintained in a standby state in which the operation of the clock 8 is stopped so as to reduce the power consumption. In this state, the CPU 5 performs no operation, and the primary battery 1 is used only for backup of data stored in the RAM 7. Therefore, only little power consumption occurs in the standby state. If the card receives a trigger signal, the clock 8 starts its operation. In this situation, the primary battery 1 supplies electric power to various circuits (the modulation/demodulation circuit 3, input and output control circuit 4, CPU 5, ROM 6, RAM 7).

Among the conventional non-contact IC cards using a radio wave as a communication medium, a batteryless type card is illustrated in Figure 9 wherein this type of card is powered by an external power supply by means of electromagnetic coupling or via an electromagnetic wave. In this batteryless non-contact IC card (referred to simply as card hereinafter) 100a, the electric power is supplied via an electromagnetic wave 20. Reference numeral 18 denotes a rectifier circuit in the form of a bridge circuit including diodes 18a-18d for converting an AC voltage of an electromagnetic wave received via an antenna 16a into a DC voltage. Reference numeral 19 denotes a storage capacitor for storing a rectified DC voltage to be supplied to various circuits via a power line 11. Reference numeral 12 denotes a GND line.

Reference numeral 16 denotes an antenna circuit for

transmitting and receiving information to and from an external device via a radio wave 20. The antenna circuit 16 includes an antenna 16a in the form of a coil and a capacitor 16b wherein the antenna circuit 16 is tuned at the same resonant frequency as the antenna of the external device. Reference numeral 17 denotes a data line via which a received signal is transferred from the antenna 16a to the modulation/demodulation circuit 3 and a signal to be transmitted is transferred from the modulation/demodulation circuit 3 to the antenna 16a, wherein the modulation/demodulation circuit 3 modulates a digital signal received from an input and output control circuit 4 into an analog signal and also demodulates a digital signal received via the antenna 16a into a digital signal. The input and output control circuit 4 converts the data from parallel and serial forms into serial and parallel forms, respectively, before transferring the data between the bus 9 and the modulation/demodulation circuit 3.

Reference numeral 30 denotes a PROM composed of rewritable and nonvolatile memory for storing data. Reference numeral 29 denotes a control circuit for controlling operations performed sequentially in the card.

In the batteryless card 100a, electric power is supplied in a manner described below.

In the case of a batteryless type, the card 100a has to rectify an AC voltage provided by an external power source via electromagnetic wave so as to obtain a DC voltage.

Referring to Figures 10 through 13, the rectifying operation will be briefly described below. When an AC voltage shown in Figure 11 is applied to a full-wave rectification circuit shown in Figure 10, a current flows through a load resistor 31 along current paths 32 and 33. The current flows

along the path 32 when the AC voltage shown in Figure 11 has a positive polarity, whereas the current flows along the path 33 when the AC voltage shown in Figure 11 has a negative polarity. As a result, the current flows the load resistor 31 always in the same direction and thus a rectified voltage having a waveform shown in Figure 12 appears across the load resistor 31. This rectified voltage is applied to the storage capacitor 19 (refer to Figure 9) so as to obtain a smoothed and stable voltage as shown in Figure 13. The smoothed voltage is applied to various circuits.

The operation of the batteryless card 100a will be briefly described below.

The card 100a operates in a manner similar to the battery-powered card 100 except for the manner in which electric power is supplied to the card. In the case of the batteryless card 100a, the operation starts when the card 100a receives a signal from a reader/writer. At the same time, the voltage of the electromagnetic wave 20 carrying the signal is rectified by the rectifier circuit 18 and stored in the storage capacitor 19. The electric power stored in the storage capacitor 19 is supplied to the internal circuits. Unlike the battery-powered card 100 shown in Figure 5 in which data can be temporarily stored in the RAM, the batteryless card 100a shown in Figure 9 cannot maintain data in a RAM when the card 100a receives no electromagnetic wave, and thus the RAM is replaced by a PROM 30 composed of rewritable and nonvolatile memory.

Conventional non-contact IC cards are constructed in the manner described above. However, the battery-powered card has a disadvantage that the primary battery has to always supply a considerable amount of electric power to the internal circuits. Further, noise or the like can cause the card to

erroneously start its operation, which results in a great power consumption. Thus, the battery will run out sooner or later and all data in the RAM will be lost. On the other hand, in the case of the batteryless card, since electric power is supplied from the outside via an electromagnetic wave, if the electromagnetic wave is too weak, the card cannot operate. This means that the communication distance is limited to a short range. Furthermore, a PROM is used in the batteryless card because RAMs cannot be employed in the card of the batteryless type. However, the PROM is slow in reading and writing operations and thus the data processing of the card is limited to a low speed.

SUMMARY OF THE INVENTION

It is an object of the present invention to solve the problems described above. More specifically, it is an object of the present invention to provide a non-contact IC card having advantages including those of the battery-powered type and the batteryless type thereby achieving a long battery life and thus a long card life, a high data processing speed, and a long communication distance.

According to a first aspect of the present invention, in view of the above objects, there is provided a non-contact IC card comprising: an antenna circuit for transmitting and receiving an electromagnetic wave serving as a medium for carrying data, and also receiving electric power carried by the electromagnetic wave; data processing and data storing means for processing and storing data, the data processing and data storing means being connected to the antenna circuit; a first power source for supplying electric power, the first power source being connected to the data processing and data storing

means; a second power source that is connected to the antenna circuit and the data processing and data storing means so that electric power received via the antenna circuit is rectified and then stored so as to supply electric power to the data processing and data storing means; and power source switching means that is connected to the first and second power sources and the data processing and data storing means in such a manner as to switch electric power supplied to the data processing and data storing means between the first and second power sources.

According to a second aspect of the present invention based on the above-described first aspect, there is provided a non-contact IC card, wherein the first power source comprises a primary battery, and the second power source comprises a rectifier circuit for rectifying electric power received via the antenna circuit, and a storage capacitor for storing rectified electric power.

According to a third aspect of the present invention based on the above-described first or second aspect, there is provided a non-contact IC card, wherein the power source switching means comprises a power supply controller that operates in such a manner that when the voltage of the second power source is higher than the operating voltage of the card, electric power is supplied by the second power source, and when the voltage of the second power source is lower than the operating voltage of the card, electric power is supplied by the first power source.

According to a fourth aspect of the present invention based on the above-described first aspect, there is provided a non-contact IC card, wherein the second power source comprises a rectifier circuit for rectifying electric power received via the antenna circuit, and a storage capacitor for storing rectified

electric power, and the first power source comprises a secondary battery adapted to be charged by rectified electric power supplied by the second power source.

According to a fifth aspect of the present invention based on any of the above-described first through fourth aspects, there is provided a non-contact IC card, wherein the data processing and data storing means includes a RAM acting as a rewritable memory, the RAM being backed by the first power source.

In the non-contact IC card according to the first aspect of the present invention, the card includes: a first power source installed in the card; a second power source for supplying electric power from stored electric power obtained by rectifying electric power of an electromagnetic wave received from the outside via an antenna circuit; and power source switching means for switching electric power supplied to the data processing and data storing means between the first and second power sources, wherein when the electromagnetic wave is strong enough, the second power source is used, and when the electromagnetic wave is weak, the first power source is used.

In the ~~a~~ second aspect of the present invention, the first power source comprises a primary battery, and the second power source comprises a rectifier circuit for rectifying electric power received via the antenna circuit, and a storage capacitor for storing the rectified electric power wherein when the received electromagnetic wave is strong enough, only the second power source is used whereas the primary battery installed in the card is used only for backup of data stored in the RAM thereby reducing power consumption of the primary battery, and when the received electromagnetic wave is weak, the primary battery is used for card operation.

In the third aspect of the present invention, the power source switching means comprises a power supply controller that switches the power sources on the basis of the card operating voltage in such a manner that when the voltage of the second power source is higher than the operating voltage of the card, electric power is supplied by the second power source, and when the voltage of the second power source is lower than the operating voltage of the card, electric power is supplied by the first power source.

In the fourth aspect of the present invention, the second power source comprises a rectifier circuit for rectifying electric power received via the antenna circuit, and a storage capacitor for storing rectified electric power, and the first power source comprises a secondary battery adapted to be charged by rectified electric power supplied by the second power source, whereby the first power source can be charged by electric power supplied from the outside via an electromagnetic wave.

In the fifth aspect of the present invention, the data processing and data storing means includes a RAM acting as a rewritable memory, the RAM being backed up by the first power source thereby achieving a higher data processing speed than conventional batteryless cards using a PROM.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a first embodiment of a non-contact IC card according to the present invention;

Figure 2 is a schematic diagram of a second embodiment of a non-contact IC card according to the present invention;

Figure 3 is a schematic diagram of a specific example of the power supply controller shown in Figure 2;

Figure 4 is a schematic diagram of a third embodiment

of a non-contact IC card according to the present invention;

Figure 5 is a schematic diagram of a conventional non-contact IC card of the battery-powered type;

Figure 6 is a schematic representation of an electromagnetic wave carrying information to be received by the non-contact IC card shown in Figure 5;

Figure 7 is a schematic representation of a waveform of a digital signal obtained by demodulating the electromagnetic wave received by the non-contact IC card shown in Figure 5;

Figure 8 is a schematic representation of a clock operation which takes place when the non-contact IC card shown in Figure 5 receives an electromagnetic wave;

Figure 9 is a schematic diagram of a conventional batteryless non-contact IC card;

Figure 10 is a schematic diagram illustrating the operation of a rectifier circuit used in the conventional batteryless non-contact IC card;

Figure 11 is a schematic representation of a waveform of an AC voltage applied to the rectifier circuit;

Figure 12 is a schematic representation of a waveform of a voltage rectified by the rectifier circuit; and

Figure 13 is a schematic representation of a voltage across a storage capacitor charged by the rectified voltage supplied by the rectifier circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the accompanying drawings, preferred embodiments of the present invention will be described below.

Embodiment 1:

Figure 1 is a schematic diagram of an embodiment of a

non-contact IC card according to the present invention. In the non-contact IC card 110 shown in Figure 1, reference numeral 16 denotes an antenna circuit 16 for transmitting and receiving information to and from an external device via a radio wave 20. The antenna circuit 16 includes an antenna 16a in the form of a coil and a capacitor 16b wherein the antenna circuit 16 is tuned at the same resonant frequency as the antenna of the external device. Reference numeral 17 denotes a data line via which a received signal is transferred from the antenna 16a to the modulation/demodulation circuit 3 and a signal to be transmitted is transferred from the modulation/demodulation circuit 3 to the antenna 16a. Reference numeral 18 denotes a rectifier circuit in the form of a bridge circuit including diodes 18a-18d for converting an AC voltage of an electromagnetic wave received via an antenna 16a into a DC voltage. Reference numeral 19 denotes a storage capacitor for storing a rectified DC voltage to be supplied to various circuits via a second power line 11a. Reference numeral 12 denotes a GND line.

Reference numeral 1 denotes a primary battery installed in the card for supplying electric power to various circuits via a first power line 10a. Reference numeral 5 denotes a CPU for processing data according to a user program. Reference numeral 6 denotes a ROM for storing the user program. Reference numeral 7 denotes a RAM for temporarily storing data. Reference numeral 8 denotes a clock for generating a clock signal in response to which the CPU 5 operates. Reference numeral 9 denotes a bus via which data and addresses are transmitted. Reference numeral 3 denotes the modulation/demodulation circuit for modulating a digital signal received from an input and output control circuit 4 into an analog signal and also demodulating a analog signal received via

the antenna 16a into a digital signal, wherein the input and output control circuit 4 converts the data from parallel and serial forms into serial and parallel forms, respectively, before transferring the data between the bus 9 and the modulation/demodulation circuit 3. Reference numeral 2 denotes a diode serving as a switch for turning on the power source connected to the first power line 10a.

The modulation/demodulation circuit 3, input and output control circuit 4, CPU 5, ROM 6, RAM 7, clock 8, and bus 9 form data processing and data storing means. The primary battery 1 serves as a first power source. Furthermore, the rectifier circuit 18 and the storage capacitor 19 forms a second power source. The first power line 10a, the second power line 11a, and the diode 2 form a power source switching means.

In the present embodiment, the card 110 includes: the primary battery serving as the first power source; and the second power source formed with the rectifier circuit 18 and the storage capacitor 19; so that electric power is supplied to various circuits from the built-in primary battery 1 via the first power line 10a and from the storage capacitor 19 via the second power line 11a wherein the storage capacitor 19 stores electric power obtained from the outside via an electromagnetic wave. The diode 2 disposed in the middle of the first power line 10a acts as a switch which operates in such a manner that if the rectified voltage which is generated by the rectifier circuit 18 by rectifying the electromagnetic wave 20 received via the antenna 16a is greater than the voltage of the primary battery 1, then electric power is supplied to the respective circuit via the second power line 11a, whereas if the rectified voltage is less than the voltage of the primary battery 1, then electric power is supplied to the respective circuits from the

primary battery 1 via the first power line 10a. The diode 2 also prevents a current flowing via the second power line 11a to flow into the primary battery 1.

The card 110 operates as follows.

The card 110 is usually in a standby state or a low-power state in which the operation of the clock 8 is stopped and thus the operation of the CPU 5 is also stopped thereby reducing the consumption of the primary battery 1. When the card 110 receives a signal via the antenna 16a from an external device such as a reader/writer (not shown), the card 110 starts its operation. At the same time, the voltage of the electromagnetic wave 20 carrying the signal is rectified by the rectifier circuit 18 and stored in the storage capacitor 19. The voltage across the storage capacitor 19 is compared with the voltage of the primary battery 1, and a voltage higher than the other is used to supply electric power to the internal circuits. After the modulation/demodulation circuit 3 obtains data, data processing is performed in the same manner as in the conventional technique, and thus further details are not described here.

In the card 110 of the present embodiment, as described above, the built-in primary battery 1 is used only for backup of data stored in the RAM 7 composed of SRAM during the standby state, as long as the electromagnetic wave 20 is sufficiently strong. Therefore, only little power consumption occurs in the standby state. Furthermore, even in the case where the electromagnetic wave 20 is weak, the card 110 can operate using the primary battery 1. This means that the card 110 can perform communication over a longer distance. Thus, in the present embodiment of the invention, it is possible to perform communication over a longer distance with higher

reliability. Compared with the conventional battery-powered card, the card 110 of the present embodiment needs less power consumption of the battery. Compared with the conventional batteryless card, the card 110 of the present embodiment can perform communication over a longer distance with higher reliability. Furthermore, the primary battery 1 installed in the card 110 makes it possible to employ an SRAM which is a nonvolatile memory capable of operating at a high speed.

Embodiment 2:

Figure 2 is a schematic diagram of another embodiment of a non-contact IC card according to the present invention. The non-contact IC card 111 shown in Figure 2 is substantially the same as the card 110 of the first embodiment shown in Figure 1 except that the diode 2 is replaced by a power source controller 14. The power source controller 14 serves as power source switching means.

The power source controller 14 is disposed between the first power line 10a and the second power line 11a so that when the voltage across the storage capacitor 19 storing energy supplied from the external via an electromagnetic wave 20 is greater than the operating voltage (5 V for example) of the card, the card 111 operates using electric power supplied from the external power source via the second power line 11a, and when the voltage across the storage capacitor 19 is less than the operating voltage of the card, the card operates using electric power supplied from the primary battery 1 via the first power line 10a.

A specific example of the power supply controller 14 is a memory card power IC (MB3790) available from Fujitsu. Figure 3 illustrates this memory card power IC. In Figure 3,

VIN denotes an input voltage terminal to be connected to the second power line 11a. VOUT denotes an output voltage terminal to be connected to the common power line 15 shown in Figure 2. VSENSE denotes an input terminal connected to a comparator for detecting the voltage level of the power source wherein a reference voltage generated by resistors 23 and 24 is applied to the input terminal VSENSE. VBAT1 denotes a primary battery terminal to be connected to the first power line 10a. CONT denotes an output control terminal for controlling the voltage supplied to the common power line 15. Other pins having no connection are not used in this embodiment.

If the voltage applied to the VIN via the second power line 11a is greater than the reference voltage (for example an operating voltage of 5 V) applied to the VSENSE, the voltage applied to the VIN via the second power line 11a is output via the VOUT to the common power line 15. If the voltage applied to the VIN is smaller than the reference voltage applied to the VSENSE, the voltage of the primary battery 1 connected via the first power line to VBAT1 is output via the VOUT to the common power line 15. The reference voltage applied to VSENSE can be adjusted by adjusting the resistances 23 and 24.

The card 111 operates as follows.

The card 111 of the present embodiment is usually in a standby state to reduce the consumption of the primary battery 1. When the card 111 receives a signal from a reader/writer, the card 111 starts its operation. At the same time, the voltage of the electromagnetic wave 20 carrying the signal is rectified by the rectifier circuit 18 and stored in the storage capacitor 19. The voltage stored in the storage capacitor 19 is applied to VIN of the power supply controller 14. If this voltage is higher than the card operating voltage applied to

VSENSE of the power supply controller 14, then the voltage stored in the storage capacitor 19 is output via VOUT to the common power line 15, and thus the internal circuits can operate.

On the other hand, if the voltage of the storage capacitor 19 applied to the VIN is lower than the card operating voltage, then the voltage of the primary battery 1 applied to VBAT1 of the power supply controller 14 is output via VOUT to the common power line 15 so that the internal circuits can operate.

After acquiring data, data processing is performed in the same manner as in the conventional technique, and thus further details are not described here.

In the card 111 of the present embodiment, as described above, the built-in primary battery 1 is used only for backup of data stored in the RAM 7 during the standby state, as long as the voltage obtained by the electromagnetic wave 20 is higher than the card operating voltage. Therefore, only little power consumption occurs in the standby state. Furthermore, even in the case where the electromagnetic wave 20 is weak, the card 111 can operate using the primary battery 1. This means that the card 111 can perform communication over a longer distance. In this embodiment, the power sources are switched in response to the result of comparison to the card operating voltage, and thus the present embodiment can provide higher reliability.

Embodiment 3:

Figure 4 is a schematic diagram of still another embodiment of a non-contact IC card according to the present invention. The non-contact IC card 112 shown in Figure 4 is

obtained by replacing the primary battery 1 of the card 110 of the first embodiment shown in Figure 1 by a secondary battery 13 so that the secondary battery 13 is charged by the voltage developed across the storage capacitor 19. Furthermore, the diode disposed in the path of the first power line 10a is removed. The secondary battery 13 acts as a first power source 10, and first and second power lines 10a and 11a form power source switching means.

An electromagnetic wave 20 is received via the antenna 16a and rectified by the rectifier circuit 18. The rectified voltage is used to charge the storage capacitor 19. If the voltage appearing across the storage capacitor 19 is higher than the voltage of the secondary battery 13, electric power is supplied to various circuits via the second power line 11a. In this case, the electric power is also supplied to the secondary battery 13 so as to charge it. On the other hand, if the voltage across the storage capacitor 19 is lower than the voltage of the secondary battery 13, the secondary battery 13 supplies electric power via the first power line 10a to the respective circuits.

The card of the present embodiment operates as follows.

The card 112 of the present embodiment is usually in a standby state to reduce the consumption of the secondary battery 13. When the card 112 receives a signal from a reader/writer, the card 112 starts its operation. At the same time, the voltage of the electromagnetic wave 20 carrying the signal is rectified by the rectifier circuit 18, and this rectified voltage is used to charge the storage capacitor 19. The voltage across the charged storage capacitor 19 is compared to the voltage of the secondary battery 13. A voltage higher than the

other is used to supply electric power to the internal circuits.

In the case where the storage capacitor 19 has a higher voltage, the voltage across the storage capacitor is also used to charge the secondary battery 13.

After the modulation/demodulation circuit 3 obtains data, data processing is performed in the same manner as in the conventional technique, and thus further details are not described here.

In the card 112 of the third embodiment, the secondary battery 13 installed in the card 112 makes it unnecessary to exchange the battery. The built-in secondary battery 13 is used only for backup of data stored in the RAM 7 during the standby state, as long as the electromagnetic wave 20 is sufficiently strong. Therefore, only little power consumption occurs in the standby state. Furthermore, even in the case where the electromagnetic wave 20 is weak, the card 112 can operate using the secondary battery 13.

In the non-contact IC card according to the first aspect of the present invention, as described above, the card includes: a first power source installed in the card; a second power source for supplying electric power from stored electric power obtained by rectifying electric power of an electromagnetic wave received from the outside via an antenna circuit; and power source switching means for switching electric power supplied to the data processing and data storing means between the first and second power sources, wherein when the electromagnetic wave is strong enough, the second power source is used, and when the electromagnetic wave is weak, the first power source is used, whereby power consumption of the first power source is reduced compared to conventional battery-powered cards, and communication can be performed even under weak

electromagnetic wave conditions and thus communication is possible over a longer distance compared to conventional batteryless cards. Thus, the second embodiment of the invention provides a non-contact IC card capable of performing communication over a long distance with high reliability.

In the a second aspect of the present invention, the first power source comprises a primary battery, and the second power source comprises a rectifier circuit for rectifying electric power received via the antenna circuit, and a storage capacitor for storing the rectified electric power wherein when the received electromagnetic wave is strong enough, only the second power source is used whereas the primary battery installed in the card is used only for backup of data stored in the RAM thereby reducing power consumption of the primary battery, and when the received electromagnetic wave is weak, the primary battery is used for card operation. Thus, the second aspect of the invention provides a non-contact IC card that is capable of performing communication over a long distance with high reliability and also has a long battery life.

In the third aspect of the present invention, the power source switching means comprises a power supply controller that switches the power sources on the basis of the card operating voltage in such a manner that when the voltage of the second power source is higher than the operating voltage of the card, electric power is supplied by the second power source, and when the voltage of the second power source is lower than the operating voltage of the card, electric power is supplied by the first power source. Thus, the third aspect of the invention provides a non-contact IC card that is capable of performing communication over a long distance with high reliability and also has a higher reliability in maintaining a proper operating

voltage.

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In the fourth aspect of the present invention, the second power source comprises a rectifier circuit for rectifying electric power received via the antenna circuit, and a storage capacitor for storing rectified electric power, and the first power source comprises a secondary battery adapted to be charged by rectified electric power supplied by the second power source, whereby the first power source can be charged by electric power supplied from the outside via an electromagnetic wave. Thus, the third aspect of the invention provides a non-contact IC card that is capable of performing communication over a long distance with high reliability and also is convenient in that exchange of the battery (the first power source) installed in the card is not required.

In the fifth aspect of the present invention, the data processing and data storing means includes a RAM acting as a rewritable memory wherein the RAM is backed by the first power source thereby achieving not only a long communication distance and high communication reliability, but also a higher data processing speed than conventional batteryless cards using a PROM.

WHAT IS CLAIMED IS:

1. A non-contact IC card comprising:

an antenna circuit for transmitting and receiving an electromagnetic wave serving as a medium for carrying data, and also receiving electric power carried by the electromagnetic wave;

data processing and data storing means for processing and storing data, said data processing and data storing means being connected to said antenna circuit;

a first power source for supplying electric power, said first power source being connected to said data processing and data storing means;

a second power source that is connected to said antenna circuit and said data processing and data storing means so that electric power received via said antenna circuit is rectified and then stored so as to supply electric power to said data processing and data storing means; and

power source switching means that is connected to said first and second power sources and said data processing and data storing means in such a manner as to switch electric power supplied to said data processing and data storing means between said first and second power sources.

2. The non-contact IC card according to Claim 1, wherein said power source switching means comprises a power supply controller that operates in such a manner that when the voltage of said second power source is higher than the operating voltage of the card, electric power is supplied by said second power source, and when the voltage of said second power source is lower than the operating voltage of the card, electric power

is supplied by said first power source.

3. The non-contact IC card according to Claim 1 or 2, wherein said first power source comprises a primary battery, and said second power source comprises a rectifier circuit for rectifying electric power received via said antenna circuit, and a storage capacitor for storing rectified electric power.
4. The non-contact IC card according to Claim 1, or 2, wherein said second power source comprises a rectifier circuit for rectifying electric power received via said antenna circuit, and a storage capacitor for storing rectified electric power, and said first power source comprises a secondary battery adapted to be charged by rectified electric power supplied by said second power source.
5. The non-contact IC card according to any preceding Claim, wherein said data processing and data storing means includes a RAM acting as a rewritable memory, said RAM being backed by said first power source.
6. A non-contact IC card substantially as herein described with reference to Figure 1, Figures 2 and 3 or Figure 4 of the accompanying drawings.

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Categories of documents

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Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.	E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.
A: Document indicating technological background and/or state of the art.	&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
X, Y	GB 2216303 A (CITIZEN WATCH) Figures 5, 6	1, 3, 5; 2 at least
X, Y	WO 92/08148 A1 (WESTINGHOUSE) page 9 line 13 to page 10 line 3	1, 3, 5; 2 at least
X, Y	US 5198647 (MITSUBISHI) Figures 2, 14	1, 3, 5; 2 at least
X, Y	US 4800255 (DATATRAK) Figure 2; column 2 line 57 to column 4 line 8	1, 3, 5; 2 at least
X, Y	US 4656472 (WALTON) Figure 1; column 4 lines 21-31	1, 4, 5; 2 at least
X, Y	US 4588880 (BOSCH) Figures 2, 3; column 9 lines 16-24	1, 4, 5; 2 at least
Y	EP 0437129 A2 (FUJITSU) Figures 1, 2, 6, 8 Abstract	2 at least

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